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NMRI

THE ROLE OF THE NAVAL MEDICAL RESEARCH INSTITUTE

IN THE DEEP SUBMERGENCE BIOMEDICAL PROGRAM

A Review and Evaluation of the Scientific Program
Proposed by the Naval Medical Research Institute
in Support of the Navy's Deep Submergence Biomedical Program

May 1969

Prepared By

THE COMMITTEE ON NAVAL MEDICAL RESEARCH

DSBMD
Division of Medical Sciences
National Research Council
National Academy of Sciences-National Academy of Engineering

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INTRODUCTION

By letter dated 7 March 1969 addressed to the Chairman of the Division of Medical Sciences (DMS), the Surgeon General of the Department of the Navy requested a review of the scientific research program that the Naval Medical Research Institute (NMRI) proposes to conduct as part of the Navy's Deep Submergence Biomedical Program (DSBP), with particular respect to:

- (1) the content and scope of a research program that the NMRI proposes to conduct, and
- (2) the impact on the over-all scientific and technical effort of DSBP if the research program proposed by the NMRI is not conducted at the NMRI.

The Chairman, DMS, in consultation with the Chairman of the Committee on Naval Medical Research, established an ad hoc panel, consisting of Committee members, to perform the study and to prepare a draft of a report for consideration by the entire Committee. This panel met at the NMRI on 31 March 1969 and received briefings by officials of the Bureau of Medicine and Surgery and of the NMRI on the Navy's over-all DSBP and the portion of it that the NMRI proposes to conduct. The panel also toured the NMRI laboratories that would be principally involved in the proposed research, including the hyperbaric chamber and the heat-stress, neurophysiology, toxicology, behavioral sciences, and bioengineering laboratories.

The draft report, prepared by the ad hoc panel on the basis of information acquired during this visit, previous Committee meetings, and previous visits to the NMRI and other Naval biomedical laboratories, was reviewed by the Committee and a mail vote was taken. Unanimous Committee approval was obtained, and this report is transmitted to the Surgeon General with the full endorsement of the Chairman, DMS, National Research Council.

SECTION I

CONCLUSIONS AND RECOMMENDATIONS

Concerning Naval Inhouse Research

The Committee believes that currently and for the long-term future the Navy's interests and objectives in Deep Submergence Biomedical Program (DSBP) underwater research and development will be broader than those of other federal agencies and of the private sector. Thus, although there may be non-Naval biomedical research resources that the Navy might use, they would have severe limitations in relation to the Navy's objectives and requirements.

It is recommended:

- (1) That the Navy develop inhouse biomedical research and

and development capabilities and programs to meet some of its own needs and to provide leadership and assistance in improving and developing biomedical research and development competence and capabilities in the private sector.

Concerning the Objectives of Naval Underwater Biomedical Research

The Committee is of the opinion that the Navy has a responsibility to the nation to extend the objective of its research and development program to the establishment of limits of human tolerance to the underwater environment in military operations. Therefore, there is need to establish a long-term program of biomedical research, possibly in the range of 20-25 years. Initially, this program should consist principally of fundamental research grounded on current knowledge and conducted so as to attain the ultimate objective in a systematic, scientific manner. Sound biomedical knowledge about the effects on man of the underwater environment at progressively deeper levels -- 1000 ft, 1500 ft, 2000 ft, etc. -- should be established as work moves toward the objective of determining the limit of human tolerance. To accomplish this purpose, a high-pressure research facility with a man rating at depths greater than 2000 ft is essential.

Even if a program with such an open-ended objective is not established, there is still an urgent need for the prompt establishment of a strong, integrated, basic-research-oriented DSBP. Current inadequacies in fundamental biomedical data in the field constitute a critical impediment to the attainment of the Navy's Deep Submergence Systems Program (DSSP) objectives. That is true with respect to the current short-term operational objective at the 1000-ft level. The base of fundamental knowledge for safe and effective operations at depths greater than 1000 ft is entirely inadequate. This unfortunate situation is the result of slippage in the development of the essential research resources in the past and the lead-time involved in developing new resources, particularly trained scientific research personnel.

It is recommended:

(2) That as a matter of high priority the Navy establish its inhouse biomedical research and development capabilities to provide for:

a. the performance of long-term basic research to obtain fundamental data on the effects on man of the underwater environment at progressively greater depths to ascertain the limits at which man can perform essential military functions, i.e., a complex permitting exposure of man to simulated depths of at least 2000 ft and of animals to greater depths; and

b. the efficient translation of the data obtained from such basic research into operational techniques through developmental and applied biomedical research.

Concerning the Selection of the Inhouse Facility to Conduct Basic Research in the DSBP

The Committee is agreed that the Naval Medical Research Institute (NMRI) offers an excellent installation in which to develop the integrated multi-disciplinary basic research portion of the DSBP that is so badly needed. It has a wealth of unique physical and personnel resources, its research approach is already appropriately oriented, and it has established valuable relationships with many excellent scientific research and advisory organizations. The use of the NMRI therefore affords economies, as well as the best promise of expeditiously developing an effective basic research program within the Navy.

If a high-pressure chamber facility for basic research in the DSBP is installed at some other Naval installation, it will be necessary to duplicate much of the laboratory technical and scientific staff assets now available at the NMRI. It would be possible to duplicate physical facilities, given sufficient time and funds. However, because of the critical shortage of personnel trained to do scientific work in this field, such a course would be wasteful and harmful to the Navy's over-all biomedical research program, as well as to the DSBP.

The Committee's preference for the NMRI does not imply a proposal that all fundamental research of interest to the DSBP be done there. Certainly, advantage should be taken of useful opportunities for research that become available within the Navy or elsewhere. The NMRI, however, could constitute a central core of expertise around which a broad program involving other laboratories could profitably be formed.

The development of a high-pressure chamber complex for basic research at the NMRI offers a timely opportunity to improve some of the NMRI's facilities that are currently substandard, such as the toxicology laboratory and the animal quarters. Thus, a single construction project offers both economies and benefits to the DSBP and the over-all Navy biomedical research program.

It is recommended:

(3) That a high-pressure chamber complex for basic research in the DSBP be built at the NMRI.

(4) That, in the construction of this facility, advantage be taken of the opportunity to improve the over-all capability of the NMRI not only to participate in the DSBP but also to enhance long-term, over-all Naval inhouse biomedical research and development.

(5) That the NMRI be developed as the Navy's center of excellence for basic research in the DSBP, but that, in the planning and construction of the facility and the planning and conduct of its program, full advantage be taken of the capabilities of other Naval, federal, and nongovernmental laboratories.

Concerning the Scope and Content of the Initial Basic Research in the DSBP

The research program that the NMRI has proposed in support of the DSBP is reasonable. Its primary focus is on the investigation of fundamental biomedical problems. It contains a good balance of early developmental studies that, when brought to the appropriate stage, can be transferred to other laboratories that are oriented to applied research and operations. It addresses itself both to the investigation of basic problems that must be answered to meet the Navy's short-term objective in the DSSP, and to the solution of basic scientific problems that are likely to hinder the attainment of long-term Naval operational objectives and requirements.

The specific research projects that constitute the work elements of the program are in general well conceived and offer promise of yielding useful data. It is possible, of course, to question some aspects of individual projects; but it is unreasonable to expect that each must now be a "perfect" experiment. At this stage in the program, a degree of trial and error is both unavoidable and healthy. It is more important that the proposed study approaches be reasonable (and they seem to be) and that there be close and continuous monitoring based on advice from all suitable sources, so that shifts in design and emphasis may be appropriate, timely, and constructive.

It is recommended:

(6) That planning for and construction of the high-pressure basic research complex at the NMRI proceed on the basis of the currently proposed research program.

(7) That the research program be closely monitored and that its design, scope, and progress be periodically reviewed by competent advisors drawn from the Navy and from appropriate outside sources.

SECTION II

The Basis of the Approach to the Assessment

The Committee adopted the approach that the proposed role of the NMRI in the DSBP can be evaluated best in consideration of the Navy's over-all objectives in the DSSP and the attendant biomedical problems that can be foreseen. For this purpose, the Committee defined as essential the factors listed below.

(1) The Navy's objective in the DSSP is to develop operational systems and techniques that will permit men to live and work for extended periods under ambient pressures at great oceanic depths. This objective is based on the assumption that it is unlikely that

during the next 10-15 years engineering developments will make it possible for men to live in a vehicle at such depths and to do exterior work without leaving the vehicle.

(2) In addition to the very high pressures,* the men will be exposed either singly or in combination to several other stresses, including at least the following:

- (a) low temperatures,
- (b) high humidity (in the underwater habitat),
- (c) artificial gas mixtures for respiration,
- (d) physical fatigue,
- (e) vibration and concussion,
- (f) reduced visibility,
- (g) impaired voice communication,
- (h) isolation and confinement, and
- (i) illness and injury

(3) The Navy's short-term objective calls for the development by 1974 of the capability to operate at depths of 1000 ft.

(4) The Navy's ultimate operational objectives have not been stated. However, in consideration of its expressed interest in constructing 2000-ft man-rated hyperbaric research facilities, it is reasonable to anticipate that operations at 2000 ft may become an intermediate objective.

(5) The currently foreseeable objective of the DSBP is to provide adequate solutions to the biologic problems incident to the objectives of the Navy's DSSP, as follows:

- (a) exposure of men in groups of four to 12 to pressures of about 450 psi for periods of up to 30 days** with intermittent exposure of some of the men to water at temperatures of 35-50 F (objective to be accomplished within 5 years); and

*As a rule of thumb, the pressure exerted by each 33 ft of sea water is equivalent to approximately 1 atm (14.7 psi). At a depth of 1000 ft, the atmospheric pressure is about 450 psi.

**In addition to the time spent in the underwater location, men will spend approximately 18 hr undergoing compression for the 1000-ft descent, about 30 hr for the 2000-ft descent, and much longer periods for decompression before returning to the normobaric atmosphere. Also, the men will be subjected to other stresses as discussed in paragraph (2).

(b) exposure of similar groups of men to pressures of about 900 psi for equal periods* and intermittent exposure to water at similar temperatures (no completion date set for attainment of objective).

(6) The 2000-ft level may not be the ultimate goal. This level is based on the theoretical deduction that the conditions prevailing at depths of about 1800 ft represent the limits of man's physiologic tolerance to prolonged exposure to underwater stresses. From the viewpoint of national security, it seems risky to accept this hypothesis without testing it. The Navy may be forced to establish in a systematic way the limits of human capability to perform military missions in the underwater environment.

The solution of the biologic problems attending accomplishment of the three objectives discussed above is formidable, principally because of large gaps in biomedical information about the effects on man of the stresses to which it is proposed that he be subjected in association with underwater military operations. Much of the information currently available is incomplete, and much more is needed. Enclosure 1 lists some currently recognized problems whose solutions are impeded by these lacks.

This is not an unusual circumstance in the early stages of a major new human endeavor. However, the DSBP offers unusually difficult challenges. There is some opinion that the study of the effects of exposure of terrestrial mammals, particularly of man, to the underwater environments under discussion may constitute an entire new field of biology. Although the validity of this statement is debatable, it is obvious that at least initially there will be a major requirement for basic research in the DSBP. And in view of the 5-year time frame that the Navy has set for the development of operational capabilities at 1000 ft, the initial success of the program will depend in large measure on the selection of the critical problems to be solved and the order of priorities among them. This in itself is a major undertaking, not only because of the pitfalls inherent in trying to assign ranks of importance to limiting biologic phenomena, but because of the need to reconcile these limitations with permissible human physiologic allowances in the performance of military duties.

On the basis of experience, some high-priority research requirements have already been identified, such as the study of the causes and prevention of rapid heat loss and the study of the narcotic effects of some inert gases. Others, such as some of those listed in Enclosure 1, have been deduced. Still others will not become apparent until the DSBP matures. The critical feature, however, is that, because of the nature of the problems being addressed, a great percentage of the required research will in the beginning be in the basic biomedical area. This research will involve in vitro studies and

*See second footnote on p. 5.

studies in animals and man. It will be complex, demanding, and time-consuming. It will necessitate the interplay of a broad range of scientific disciplines. It will require the employment of researchers with skills that can be acquired only by special training, and it will require the use of special and expensive research facilities.

As concerns the current state of the research and the capabilities that need to be developed, the available information is inadequate to solve all the currently identified biomedical problems involved in implementation of the Navy's 1000-ft depth objective. It is possible, of course, to gain the required knowledge within the next 5 years. However, because so much of the research that needs to be done is in the category of basic research, because of the lag in the operational application of basic research data, and because available research resources are limited, there is reasonable doubt that the 1974 objective can be completely met. It is obvious that to do so will require expenditure of considerably more effort and resources. The biomedical informational base on which to develop a 2000-ft operational capability is very inadequate. And there is no solid information about man's limit of tolerance to underwater environments. The biomedical research needs in the latter two areas, therefore, are largely basic. The development of the resources required for such research is now only in the planning and discussion phase.

SECTION III

Resources for Research in the DSBP

In consideration of the costs and magnitude of the biomedical research effort that is contemplated, the Committee is of the opinion that it is essential to make optimal use of the nation's research resources in both the private and public sectors. The Committee endorses this concept but believes that its application in meeting the Navy's needs must be on a highly selective basis.

In the United States at present there are 50-60 pressure chambers, including those at Naval installations and those in nonmilitary facilities. However, in the frame of reference in which pressure chambers are discussed in this report, all but a few of them represent a limited asset. Most of them have a rating of only a few atmospheres, they do not have wet pots, and they are used principally for therapeutic purposes. A few have wet pots and are used for research studies, principally on animals. Two chambers in universities have a man-rated capacity of 1000 ft, and both were developed with Navy support. However, only one of those is fully adequate. The Navy has 30 chambers. The two largest, having man-rated capacities of 1000 ft, are at the Experimental Diving Unit (EDU). The EDU, which is a Bureau of Ships facility, is used primarily for the development and testing of equipment and materiel for underseas projects. The research is done primarily

on "hardware"; biomedical measurements are only incidental to this work and are not a part of a defined long-term biomedical research effort. As stated previously, no 2000-ft chamber facilities are available currently in this country.

The national re-awakening of interest in underwater exploration and development is relatively new. It can be safely assumed that commercial and other interests will construct more chambers as time goes on, but it is important to consider the range of interests of the Navy and of the private sector. Currently, and for possibly the next 25 years, the primary focus of commercial and other nonmilitary interests is on the exploration and development of the continental shelf. For economic and other utilitarian reasons, the depths that are important to these interests range only up to 1000 ft. The Navy's interests, being those of the nation's military security, should extend beyond this range. Although nonmilitary facilities may now be available for use in assisting with the Navy's over-all research and development programs and others may become available in the future, they do and will continue to have serious limitations with respect to what the Committee considers to be the Navy's ultimate objective.

In terms of money and personnel, the cost of the high-pressure research facilities that are needed may be prohibitive for any organization but the federal government. The Committee understands that the estimated cost of construction of a 2000-ft research chamber facility is now several million dollars. To be effective in scientific biomedical research activities, such facilities must be supplemented with a number of laboratories staffed by highly trained researchers in many different scientific disciplines. It is difficult to identify an organization in the private sector that has the capability of developing such a facility within its own resources.

Thus, although there are and will be nonmilitary research and development resources that the Navy may use, full reliance cannot be placed on them. In this respect, the Navy's underwater program is in a situation similar to that of the atomic energy program at the end of World War II. (Because of differences of breadth of interests, availability of resources, and inherent expertise, only the government was capable of providing the leadership and impetus to develop the nonmilitary uses of atomic energy.) As opportunities are presented for profitable return from underwater development, however, interplay between the private and public sectors should expand. It is possible that well-defined research problems will be identified by the Navy that may be contracted to university or other nonmilitary research laboratories with mutual benefit. There seems to be no acceptable alternative currently, however, to the Navy's establishing its own inhouse DSBP research and development resources and programs.

Some industrial and academic institutions at home and abroad have information and experience in planning and constructing such research resources and in planning and conducting the research itself. It seems desirable for the Navy to seek advice from those institutions. In view of the critical shortage of trained research personnel in the field, it also seems desirable

for the Navy to explore the feasibility of interchange of such personnel between Naval and non-Naval laboratories.

SECTION IV

Concerning the Role of the NMRI in the DSBP

In recent years, the Committee has made several statements concerning the NMRI with respect to biomedical research in the Navy in general and the NMRI's potential role in the DSBP. Two of these statements are contained in Enclosure 2. Their principal theme is that the NMRI is uniquely suited to conduct fundamental, long-lead-time biomedical research for the Navy, as well as to initiate mission-oriented studies on high-priority developmental projects, and that for several years the NMRI has been engaged in basic and developmental research in support of the DSSP in anticipation of the establishment of official Navy operational objectives.

Since 1964, the Committee has visited all the major Naval biomedical laboratories in the United States and overseas and in each instance considered the potential contributions they might make to a vigorous, integrated DSBP. During this period, the Committee has been asked for advice concerning the development of research resources in several laboratories in support of the DSBP and has responded formally to two of these requests. It has recommended the development of 2000-ft research pressure facilities at the Submarine Medical Center (SMC), New London, and at the NMRI.

The Committee has made these recommendations after considering the different purposes for which new high-pressure chambers are being proposed within the Navy and the unique aspects of hyperbaric biomedical research. In this respect, the Committee understands that the Navy plans to construct a 2000-ft chamber at Panama City, primarily to conduct materiel testing and bioengineering studies. The successful operation of this facility presupposes the establishment of human tolerances and capabilities to perform at 2000-ft depths. The function of the laboratory would then be to develop and test the physical means and operational techniques to make it possible for men to perform adequately within established human limitations.

In recommending construction of a 2000-ft chamber facility at the SMC, New London, the Committee understood that it is being proposed as a facility intended primarily for applied and developmental biomedical research on life-support equipment and systems, and not as a basic biomedical research facility. In this respect, the Committee has noted several deficiencies in the SMC as it is now structured that limit its usefulness as a primary basic research facility in the DSBP. The Committee now reaffirms its recommendations for a high-pressure facility at the SMC primarily for developmental and applied research in the DSBP and for the conduct of such basic studies in the field for which it has the necessary resources and which it would be in the best over-all interests to conduct at that center. The Committee is also of the

opinion that the ultimate capability of this facility should be geared to using a pressure chamber man-rated at 2000 ft and that the Navy will have need for such a facility for 20-25 years. Whether the complete facility should be built in increments or constructed at this time to serve its full function is, in the opinion of the Committee, an administrative decision. From the scientific viewpoint, an operating complex adequate to deal with the research and developmental problems at the 1000-ft level seems to be adequate for the next 5-10 years. The Committee is led to this view because it is unlikely that new basic biomedical data derived from research in a 2000-ft man-rated facility will become available for developmental studies before that time. However, the Committee recognizes the possibility that construction of a 2000-ft pressure chamber at the SMC now might be the most economical procedure in the long run.

The Committee is mindful of the heavy costs involved in constructing high-pressure complexes for whatever purpose, and has carefully considered the need for high-pressure biomedical research complexes within the Navy. The Committee is still of the opinion that the Navy needs at least two such research complexes because of the volume of the work that needs to be done and the time required to complete the work. As mentioned earlier in this report, required information is lagging far behind even the currently stated objective of the Navy. This lag must be reduced while research information is acquired to support foreseeable new objectives and requirements. In effect, therefore, 10 years' work must be done within the next 5 years. Unfortunately, this task cannot be accomplished simply by more diligent application by research personnel, because the nature of the research imposes some limits on rates of progress. For example, because of the time required for compression, decompression, and actual exposure of men or animals to the experimental situation, a single experiment may take weeks to perform.

The Committee is therefore of the strong conviction that a research complex should be developed at the SMC for the purposes discussed above, and another at the NMRI to serve as the primary facility for basic research in the DSBP. From this viewpoint, the Committee assessed the NMRI's facilities, staff, relationships with the scientific community, and current and proposed scientific interests and capabilities.

In reviewing the over-all situation within the Navy, the most striking feature is that the NMRI, in conjunction with the EDU, represents the closest approach to a basic research laboratory in underwater biomedicine that exists in the Navy. However, because of their relatively low pressure ratings and for other reasons, the chambers at the NMRI are inadequate for the type of program that is needed to support the Navy's current 1000-ft objective. The EDU chamber has adequate pressure rating, and is accessible to the NMRI. However, the inefficiencies inherent in having a critical piece of research equipment located at a distance from the central laboratory and used primarily for other than biomedical research purposes are too well known to belabor. In effect, the Navy does not possess a biomedical research laboratory that is adequate to support basic research needed for its current operational objective.

Suitable land for new construction is available at the NMRI, and it already has several laboratories that are essential in the conduct of productive basic research in the DSBP. These include the microbiology and biochemistry laboratories and the clinical investigation center, which with relatively minor modification could make valuable contributions. Other facilities and laboratories at the NMRI, particularly the toxicology laboratory and the animal quarters, are not entirely adequate to support the NMRI's proposed research in the DSBP. However, the animal quarters are substandard in any event and will need to be improved, whether or not the NMRI expands its role in the DSBP. In consideration of over-all physical needs for a high-quality basic DSBP research facility, including the land and supporting laboratories, the NMRI has much to offer.

The staff of the NMRI has several outstanding investigators in a number of scientific disciplines that are essential to the conduct of an integrated basic research effort in the DSBP. These persons could easily be used in an expanded DSBP, inasmuch as several of them are already conducting preliminary underwater biomedical research studies using NMRI and EDU facilities. As the Committee has stated previously, there is a need for improvement in the staffing of the NMRI, in view of its continuing role in over-all biomedical research in support of the Navy, and this problem will need to be handled regardless of the DSBP.

Currently, the NMRI is inadequately staffed with persons specially trained in high-pressure research to carry out the part of the DSBP that the NMRI has proposed, and personnel augmentation will be required if the new high-pressure facility is constructed there. This situation is not unique to the NMRI, however, in that there are few such persons in the entire Navy. This category of personnel represents a precious resource that should be conserved. To make the best use of this resource, these persons should be brought together in a facility that has adequate space and equipment and an attitude and tradition of basic biologic investigation, so that they can interact with each other and with investigators in other scientific fields. Given new physical facilities, the NMRI offers an unusual opportunity to develop a center of excellence for basic research in support of the DSBP.

The NMRI is advantageously located. Being situated at the Naval Medical Center, it has available to it a large number of medical, dental, and related service and scientific research facilities, including an excellent hospital. It is adjacent to and enjoys close working relationships with the National Institutes of Health. It has excellent rapport with other federal laboratories in the immediate vicinity of Bethesda, including the Walter Reed Army Institute of Research and the National Bureau of Standards. It has immediate access to the Bureau of Medicine and Surgery, the Office of Naval Research, and other top-echelon research and operational commands in the Navy and the Department of Defense. In addition to its own excellent specialized library, it can call on vast local library resources, including the National Library of Medicine, the Army Medical Library, and the Library of Congress. It can use the scientific resources offered by three local

medical schools and many private laboratories working in diverse fields of science in the Washington area. It has direct access to many scientific advisory bodies, including the National Academy of Sciences, the Armed Forces Institute of Pathology, and the Armed Forces Epidemiological Board. However, the most significant factor is not so much the existence of the several organizations noted above, but the fact that, by reason of long-established competence in biomedical research, the NMRI already has their respect and has established fruitful working relationships with them.

Enclosure 1

CERTAIN BIOMEDICAL PROBLEMS IN THE DEEP SUBMERGENCE BIOMEDICAL
PROGRAM ABOUT WHICH CURRENT INFORMATION IS INADEQUATE

1. The effects of perfusion, diffusion, temperature, and oxygen tension on inert gas transport mechanisms in tissues.
2. Mechanisms of respiratory heat loss at depths at and below 1000 ft.
3. The effects on human performance of mechanical loads on the respiratory system imposed by dense gases, changes in ventilation distribution influencing pulmonary gas exchange, and respiratory control mechanisms.
4. The effects of high pressure on O_2 uptake and CO_2 excretion within the terminal lung unit.
5. The effects of high pressure on respiratory control mechanisms.
6. The role of certain physiological factors, such as sweat production and control, and electrolyte and water balances, in man's tolerance to heat stress in underwater habitats.
7. The effects of inert gases and increased CO_2 levels on neurophysiological functions.
8. The toxicity of trace contaminants at high pressures.
9. The effects of hyperbaric underwater environments on human behavior.
10. The methods controlling the transfer of inert gases in the micro-circulation.
11. The effects of high pressure on the metabolism, toxicity, and efficacy of drugs.
12. Human nutritional requirements in underwater environments.

Enclosure 2

Excerpts from

REPORT ON CERTAIN ASPECTS OF THE
NAVY BIOMEDICAL RESEARCH PROGRAM - PART II

November 1968

Committee on Naval Medical Research

"Over-all Assessment [Pages 15 and 16]

"In approaching its review of the NMRI, the Committee took cognizance of its unique character among Naval biomedical research laboratories. Most other such laboratories are located near major Naval installations in which biomedical research needs arise. Thus, those laboratories, such as the ones at Pensacola and New London, are occupied primarily with research in support of a particular Naval operational activity. Other laboratories are primarily concerned with research relating to certain disease problems. For example, NAMRU #4 emphasizes studies on respiratory diseases among recruits. Thus, the research in these other laboratories is oriented primarily toward the missions of individual operational elements of the Navy.

"The NMRI, being located close to the Bureau of Medicine and Surgery and other headquarters agencies with over-all cognizance and direction of Naval biomedical research, is concerned largely with the longer-range research needs of the Navy as a whole. Thus, NMRI is often the place in which problems with new theoretical possibilities are studied. Sometimes, after the preliminary work is completed, these studies are transferred to other laboratories for continuation; sometimes they remain as part of the NMRI program. The NMRI also provides a research back-up function. Not infrequently, other laboratories refer research problems which are beyond their competence to handle to the NMRI for solution, and frequently call upon the Institute to conduct collateral studies in specialized areas on problems of contemporary interest.

"For these reasons, the NMRI program is more basically oriented than those of other Naval biomedical laboratories and thus is especially vulnerable to the effects of fluctuations in funding for basic studies. The NMRI program, however, has continued to include mission-oriented research projects that bear immediate relevance to Naval operational problems. (Currently, for example, the Institute is conducting developmental research on heated suits for use in the Deep Submergence Systems Program.)

"Also, it is unlikely that a single study can provide answers to the complex problems undertaken by the Institute. In the relatively new and complex areas of research in which the Institute is engaged, long-range planning is essential to define a coordinated program in which a series of integrated experiments, possibly extending over several years, are directed toward stepwise solutions of parts of a problem and its ultimate answer. In such endeavors, flexibility must be maintained to adjust to the ever-changing scientific and technological environment. Success in such undertakings requires research planning and the maintenance of research capability over several years; both these requirements can be met only through stability in staffing and funding.

"Based on this approach, and having reviewed the major work in the 10 departments that constitute the NMRI, the Committee agreed:

"1. That the over-all program of the Institute has a good balance of high-quality basic and applied research that bears appropriate relevance to the Navy's current and long-range biomedical problems.

"2. That the competence of the staff is excellent, but there is urgent need for the recruitment, selection, and training of personnel, particularly professional personnel, to carry on the programs in the future.

"3. That special attention should be paid to stability of the funding and staffing of the NMRI because of the nature of its primary research efforts and in order to maintain a good balance of basic and applied research."

"NMRI Participation in the Deep Submergence Systems Program (DSSP) [Pages 19 and 20]

"During the spring of 1967, individual Committee members reviewed the research relating to the DSSP being conducted at the Experimental Diving Unit (EDU) and the NMRI. This review involved site visits and detailed discussions with research directors and investigators. At its meeting in June 1967, the Committee paid special attention to the review of research being conducted in the several departments of the Institute for the purpose of evaluating relevance and applicability to the DSSP. The Committee also acquired information about the current and longer-range development in the DSSP as concerns the NMRI program and that of the Navy as a whole.

"The Committee noted that it had expressed itself on the over-all DSSP twice in the recent past^{1,2} and saw no need to do so currently.

1. Statement concerning the Naval medical research program in underwater operations, 23 February 1965. (NRC Committee on Naval Medical Research.)
2. Report on certain aspects of the Navy biomedical research program, May 1966. (NRC Committee on Naval Medical Research.)

The Committee agreed, however, on the importance of commenting on the NMRI participation in the Program.

"The Committee noted with approval the recent improvement in the liaison between the NMRI and the EDU and the interest that had been generated in the Departments of the Institute. The Committee was pleased to learn that studies were being conducted on the effects of high pressures at the biochemical and cellular levels, high-pressure pharmacology, body temperature regulation, parabionosis, decompression, and behavioral effects of isolation and confinement. These beginnings could be the basis for the development of a very useful integrated NMRI research program in support of the DSSP.

"However, the over-all NMRI research efforts in support of the DSSP appear to be handicapped by the lack of well-defined goals and priorities. It seemed to the Committee that this situation was due to a lack of formulation of over-all Navy program requirements. In view of this situation, the Committee commended the Surgeon General and the NMRI for having already done so much in anticipation of over-all Navy requirements. The Committee agreed, however, that if the Navy expects to have a reasonable DSSP competence within 5 to 10 years, over-all goals should be more precisely outlined and priorities should be assigned promptly. Increased efforts should be made to introduce and coordinate the competence, experience, and knowledge in research of the NMRI into the planning and execution of operational trials, such as the Sealab series. Also, to make optimum use of existing research resources that the NMRI has available for use in support of the DSSP, the Committee strongly endorsed the Bureau of Medicine and Surgery FY 1969 and 1970 proposals for alterations and construction at the NMRI, especially proposed installation of a 2000-foot pressure facility and associated laboratory space."